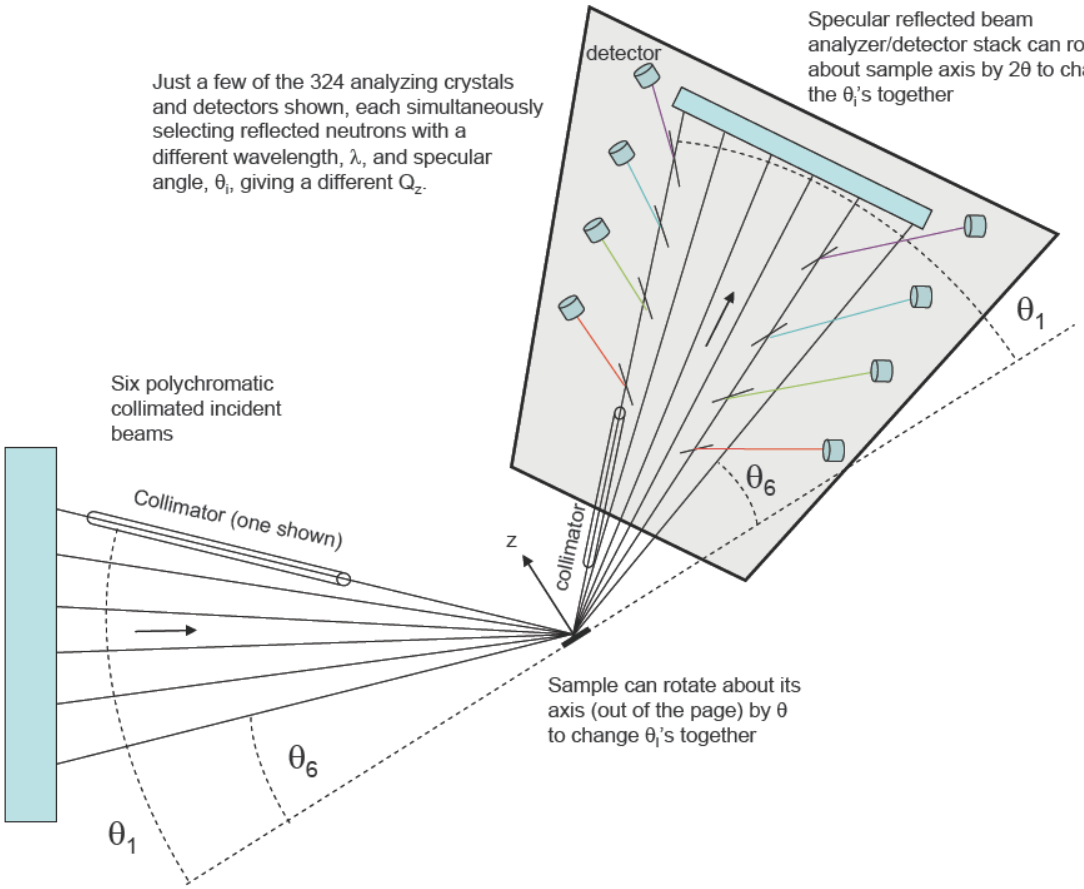
COMAND – Chromatic Optimized Multiple Analyzer Neutron Detector

J. Ziegler, D. W. Lee, C. Majkrzak,
B. Maranville, N. Maliszewskyj

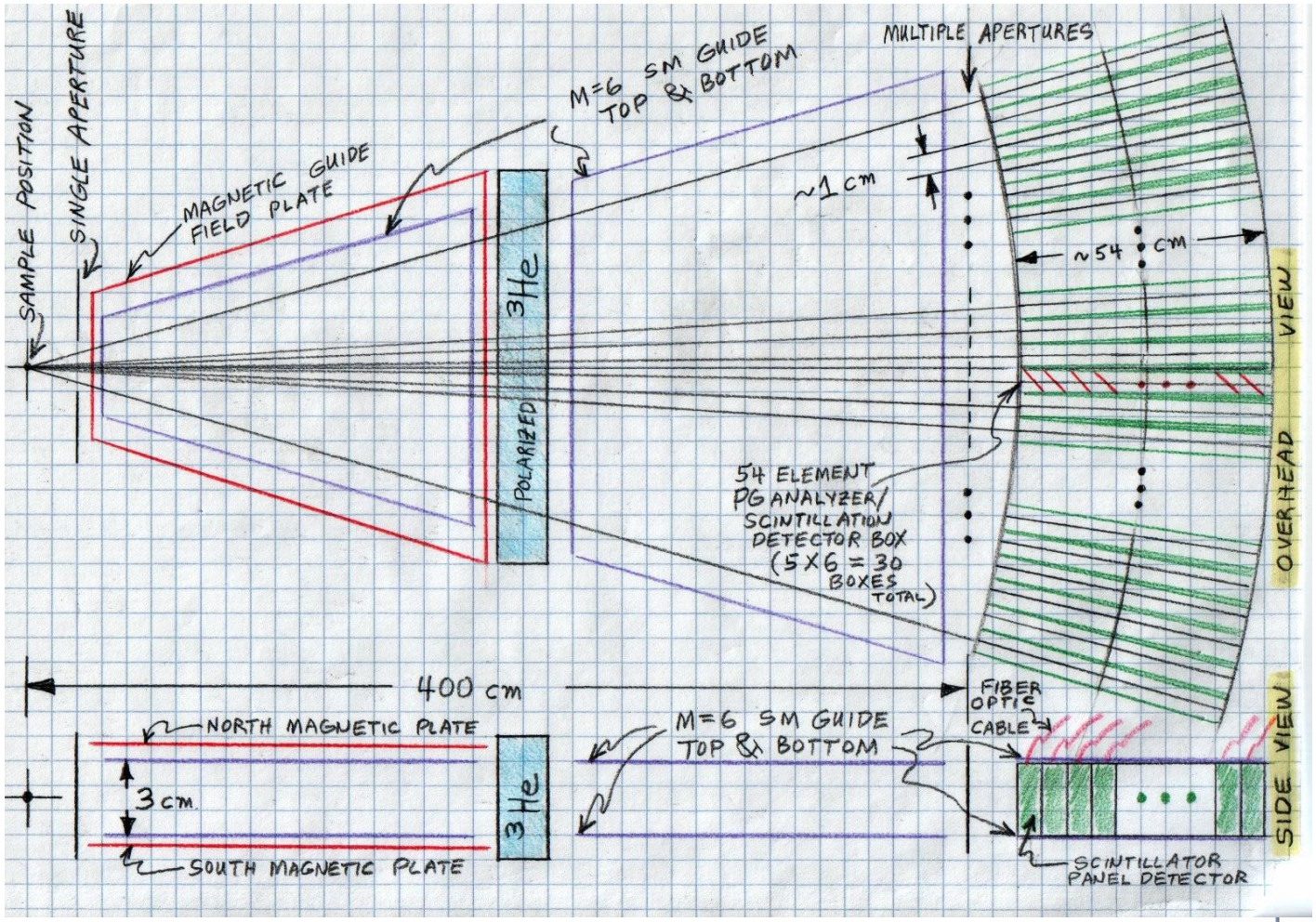
NIST Center for Neutron Research

CANDOR



NIST Center for Neutron Research

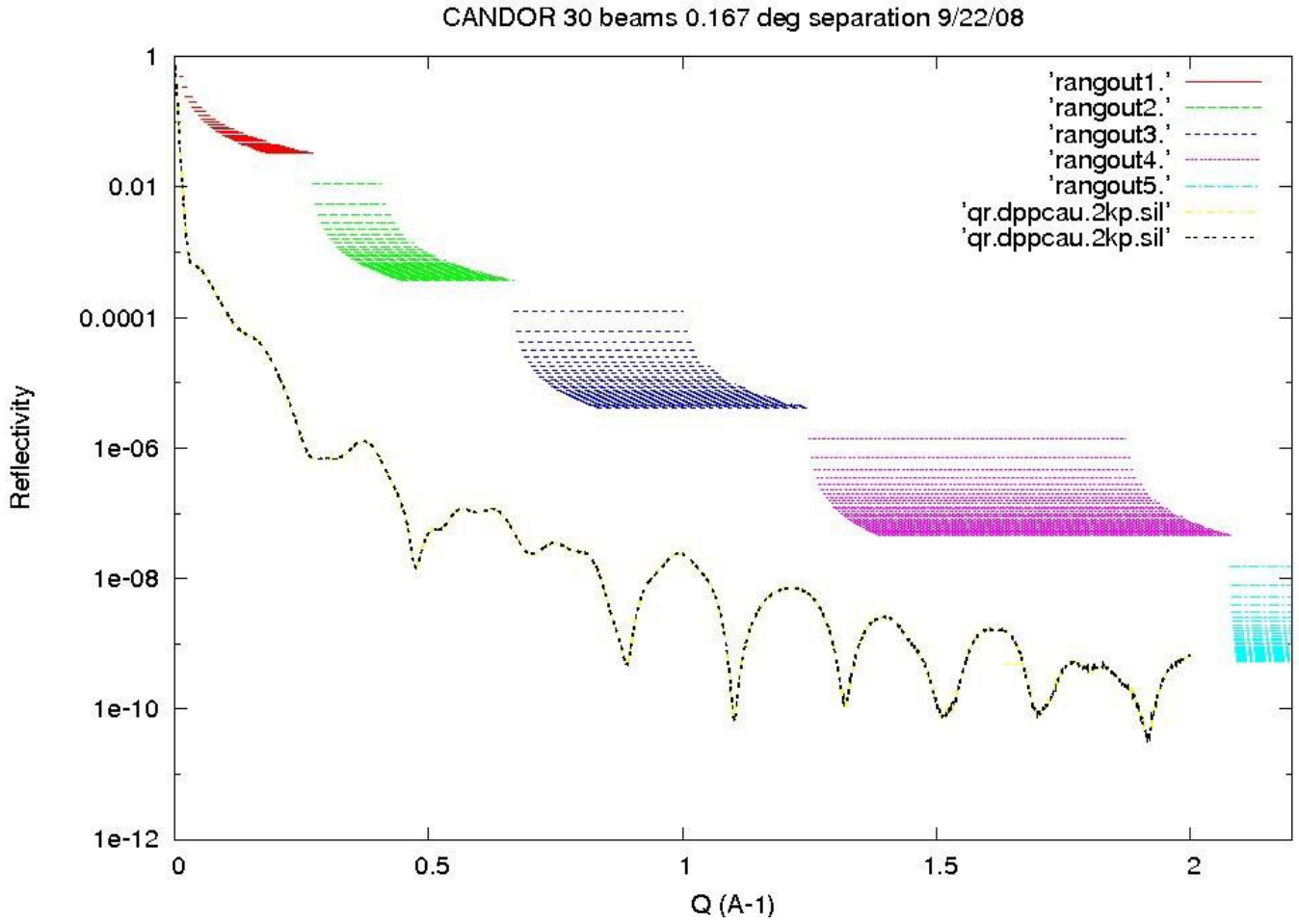
CANDOR Analyzer Array



Simultaneously collect reflectivity data from 1620 channels

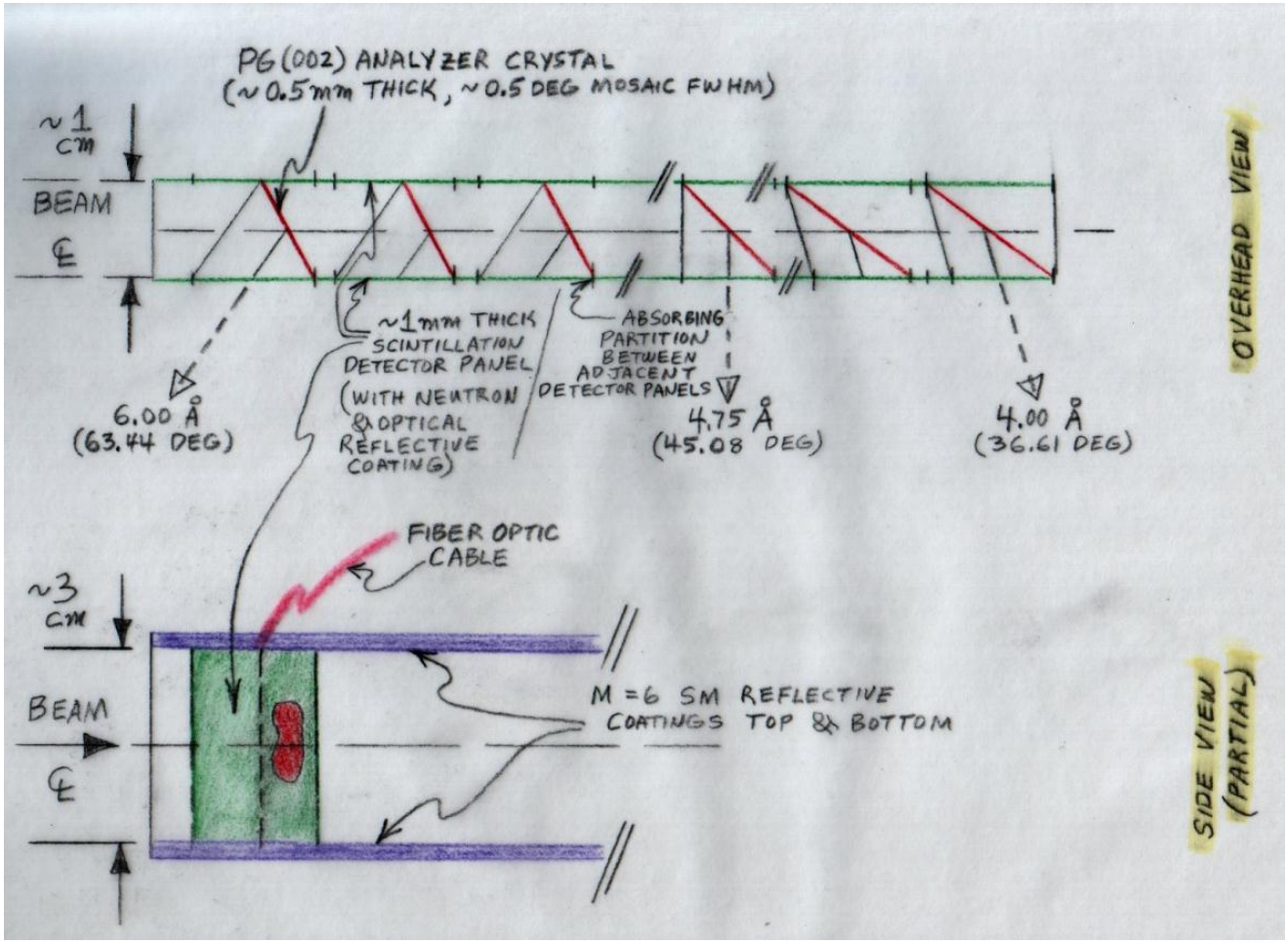
NIST Center for Neutron Research

Spectrometer Coverage



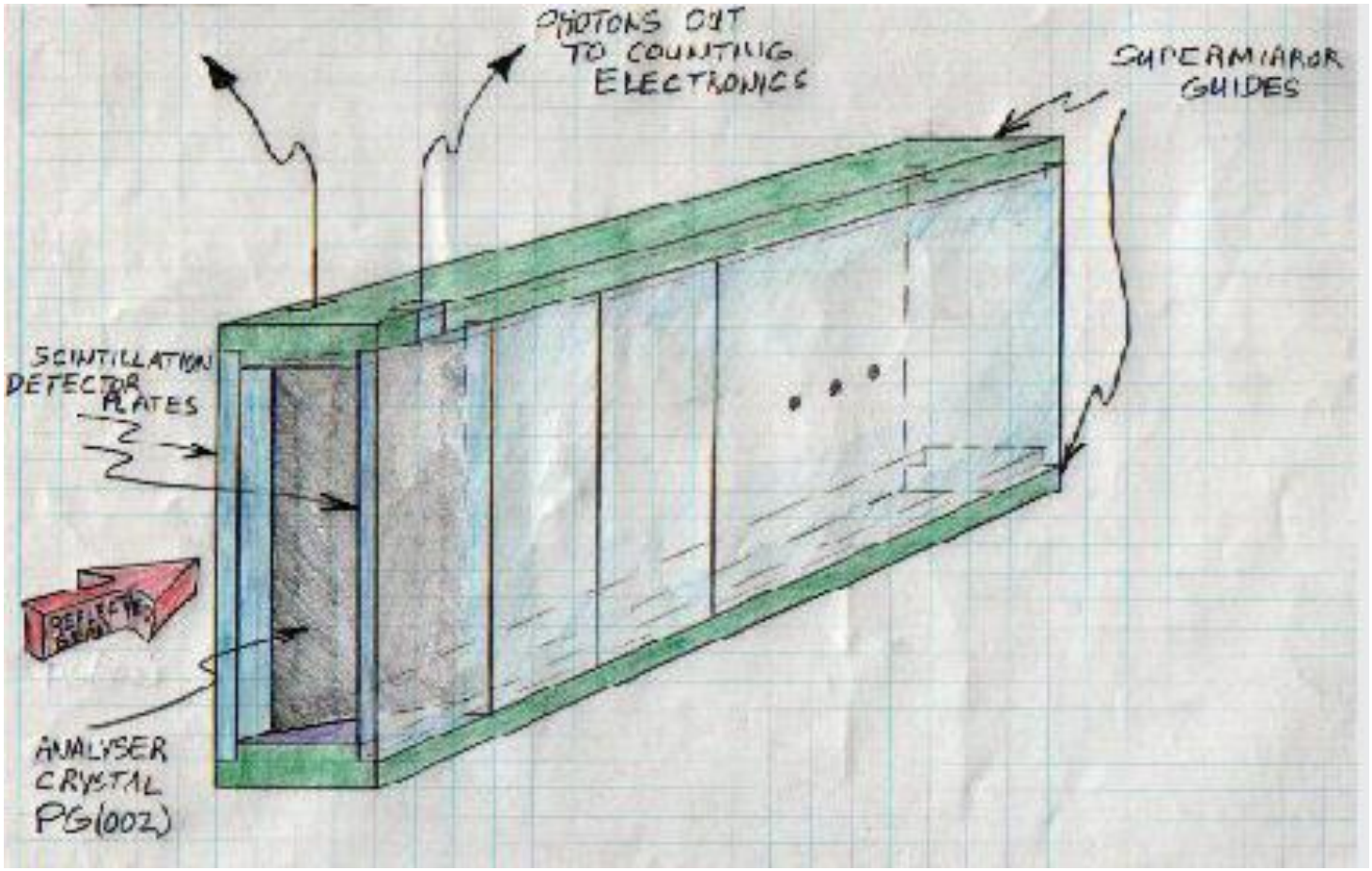
NIST Center for Neutron Research

CANDOR Analyzer Array



NIST Center for Neutron Research

CANDOR Analyzer Array



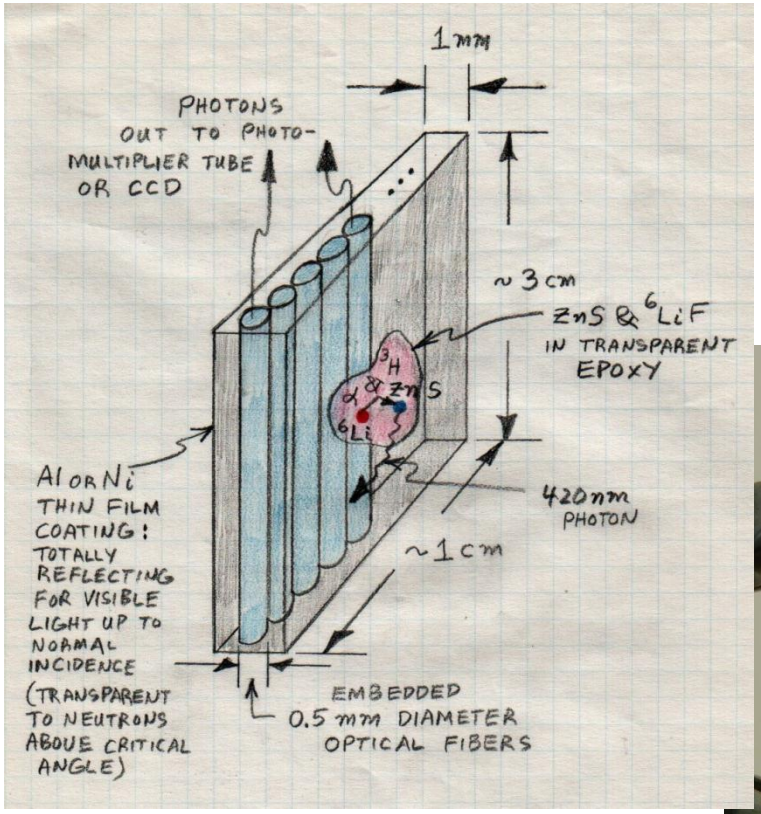
NIST Center for Neutron Research

Characteristics of Neutron Sensor

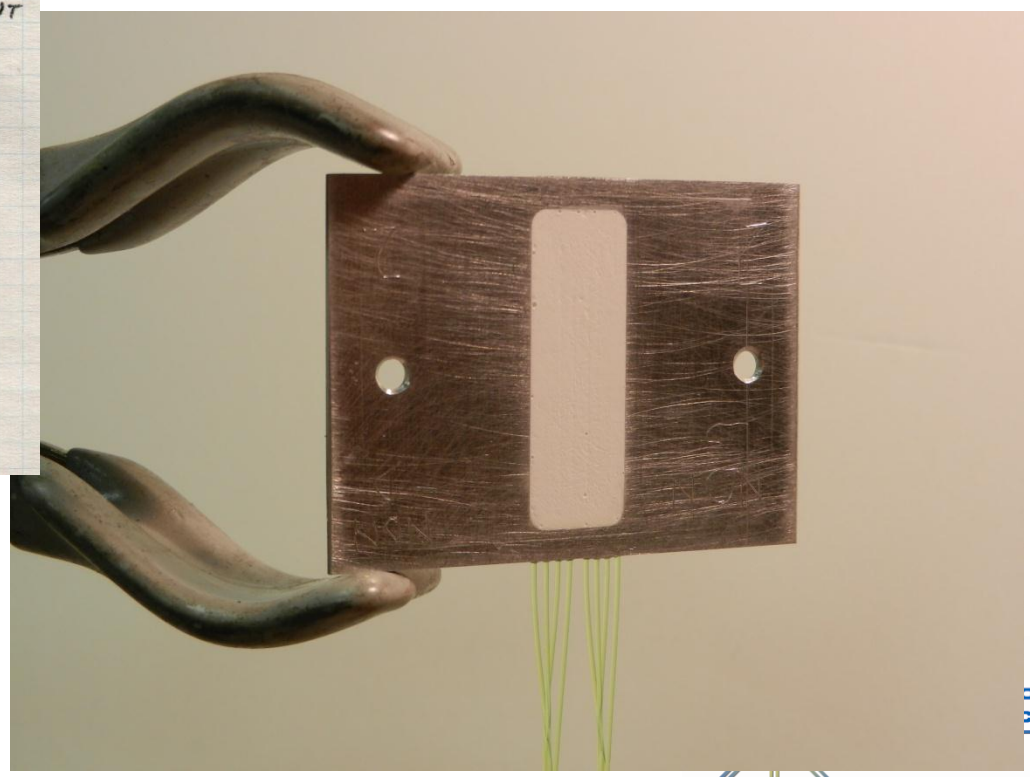
- Highly efficient neutron detection (target 90%)
- Good neutron/gamma discrimination ($\approx 10^7$)
- Sensitive area 1 cm × 3 cm
- Extremely thin (≈ 1 mm)

NIST Center for Neutron Research

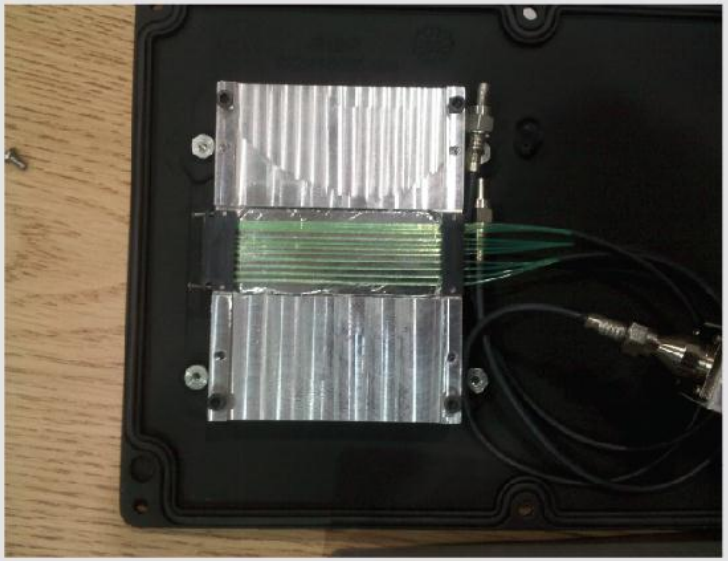
Neutron Converter Element



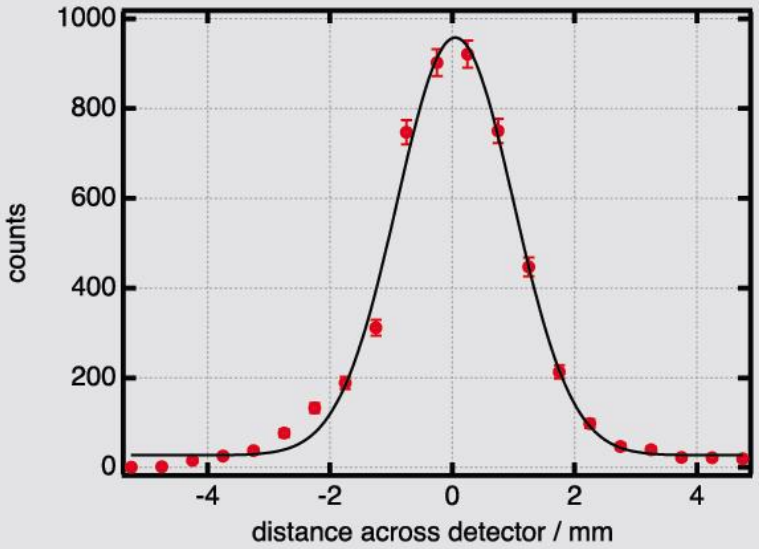
- ^{6}LiFZnS(Ag) scintillator
  - Eljen Technologies (EJ-426-ALC)
- WLS Fibers conduct light to concentrator
  - Kuraray Y-11 (500)
- SiPM photosensor
  - Zecotek, sensL, CPTA, Hamamatsu



Neutron Converter Element



Top: Test model of a scintillation detector. The optical fibres (green) will be embedded in the lithiated scintillator material.



Top: Scan of a neutron beam across the detector prototype in a direction normal to the fiber orientation. The target is an efficiency of >90%.

NIST Center for Neutron Research

Innovations in Measurement Science

- NIST Competitive Intramural Funding

- COMAND award in 2011
  - $500K/yr for 3 years
  - Renewable for an additional year

NIST Center for Neutron Research

Project Timelines

- **Year 1** (*Single Element*) Optimization of neutron detection performance (test and characterize embedding of WLS fibers in scintillator material including minimization of ϒ sensitivity)
- **Year 2** (*Single Element*) Development of electronics suitable for SiPMs (test and characterize light-to-current proportionality, optimize ϒ discrimination). Development of process to plate scintillator slabs with absorbers and Ni to form guide channels.
- **Year 3** (*Module*) Design, construct, and test modular energy dependent array of analyzers and scintillation plates
- **Year 4** (*Module*) Completion and testing of prototype

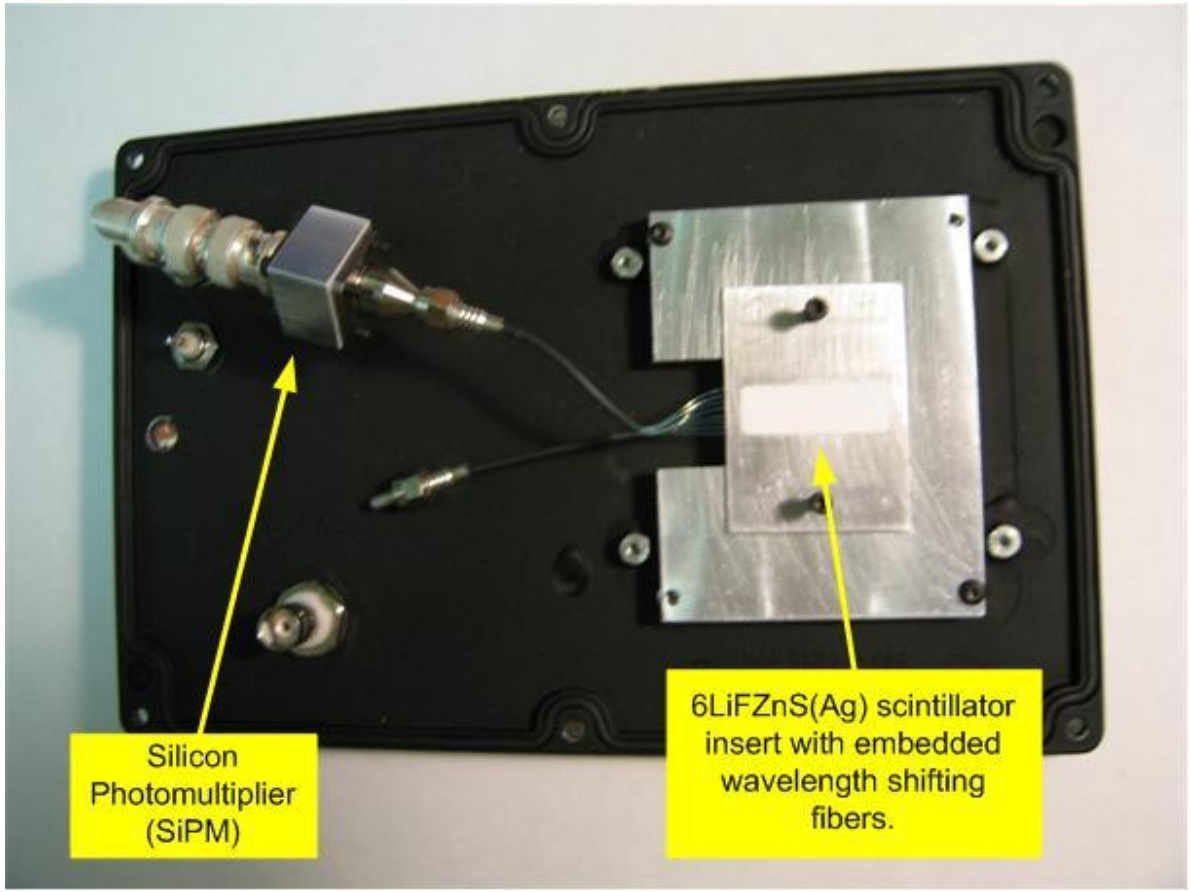
NIST Center for Neutron Research

Project Staffing (Fulltime)

- Detector Development Specialist
  - Dr. Dongwon Lee
- Electrical Engineer
  - Mr. Jeffrey Ziegler
- Data Acquisition/Software Engineer
  - Recruiting

NIST Center for Neutron Research

Test Rig for Embedded WLS Fibers



NIST Center for Neutron Research

NG1 Test Beam

$\lambda = 4.75$ Å (3.62 meV)

$\delta\lambda/\lambda \approx 1$ %

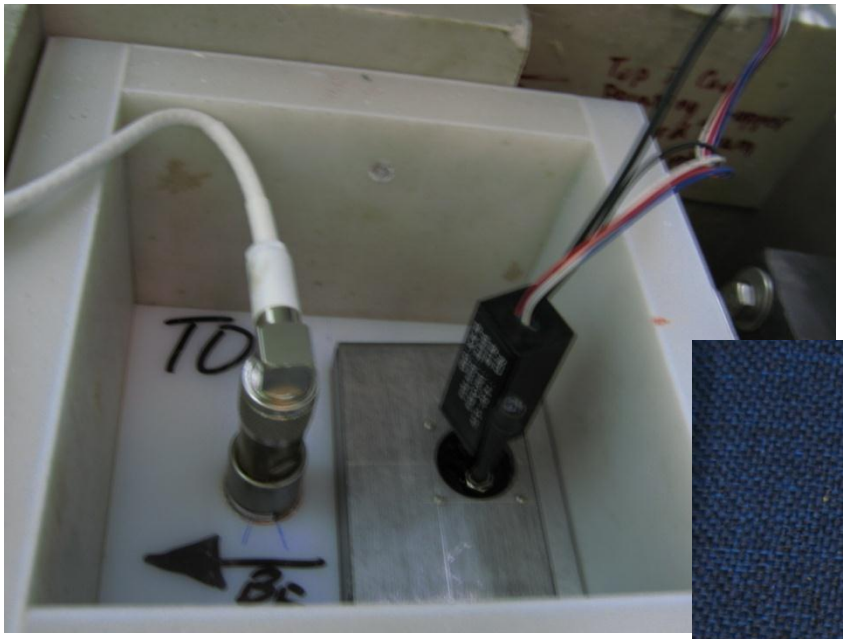
$\delta\theta_{horiz} = 1°$

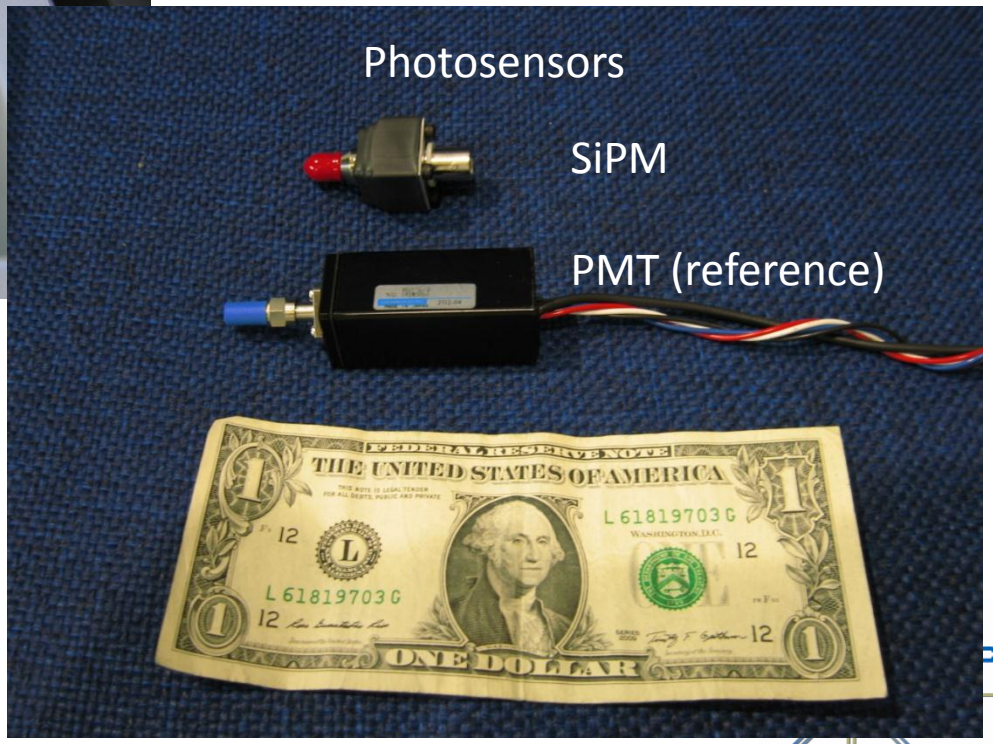
$\delta\theta_{vert} = 2°$

$J_n(27\ mm^2) \approx 750$ Hz

NIST Center for Neutron Research

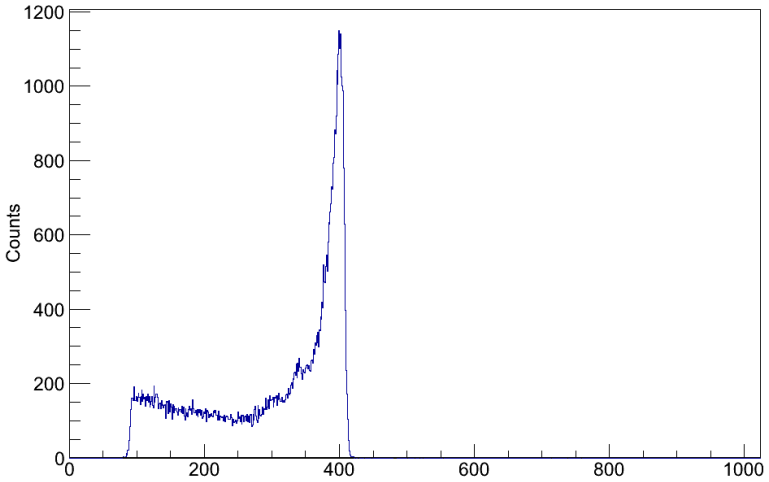
Test Rig





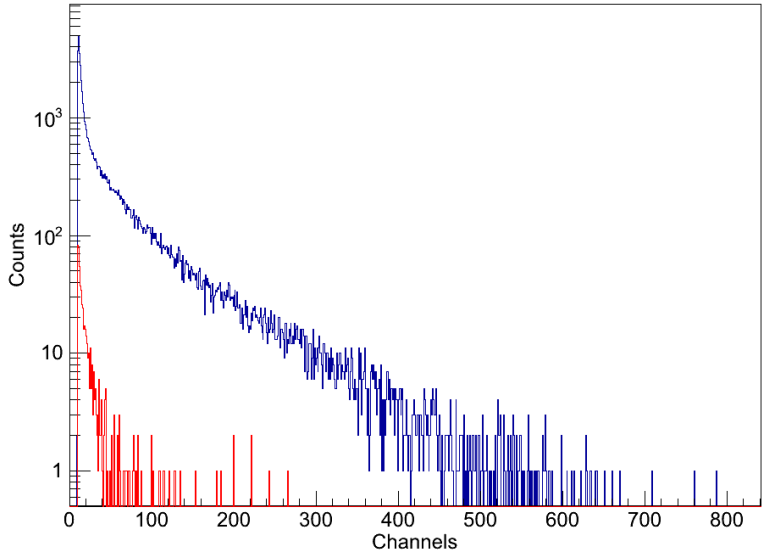
Center for Research

Pulse Height Discrimination



^{3}He Gas Filled Tube

- Can use pulse height discrimination



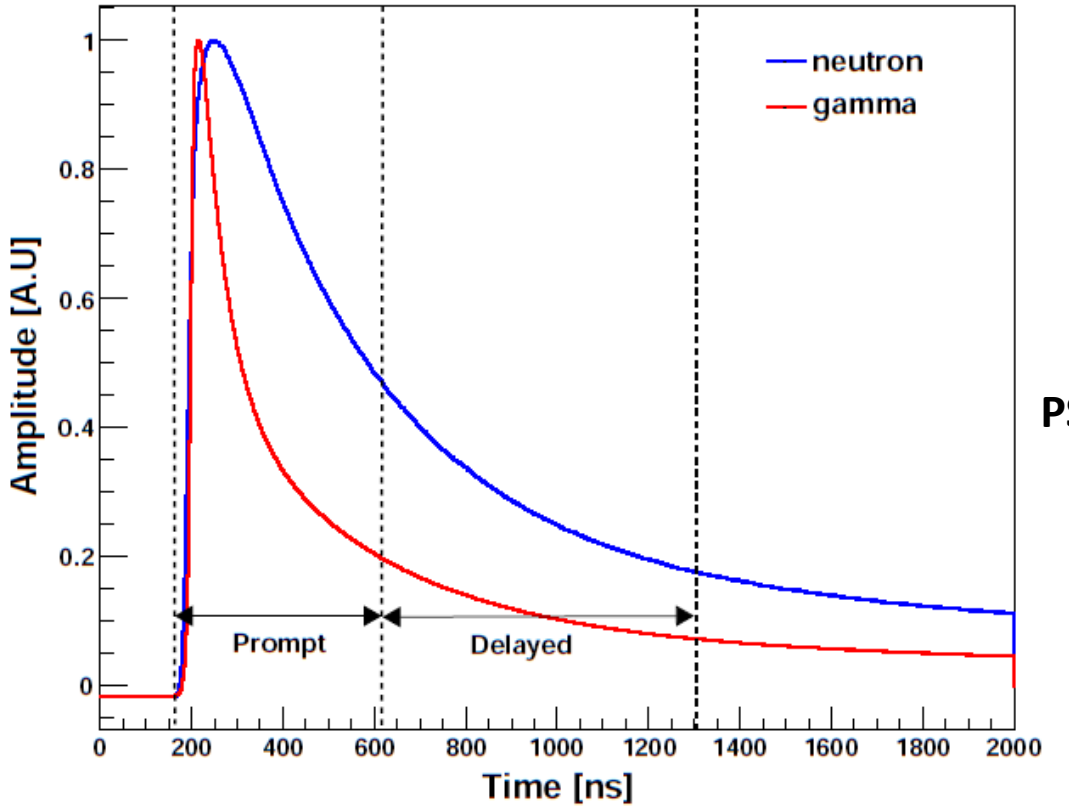
Scintillator

- Pulse height discrimination is problematic

NIST Center for Neutron Research

Pulse Shape Discrimination

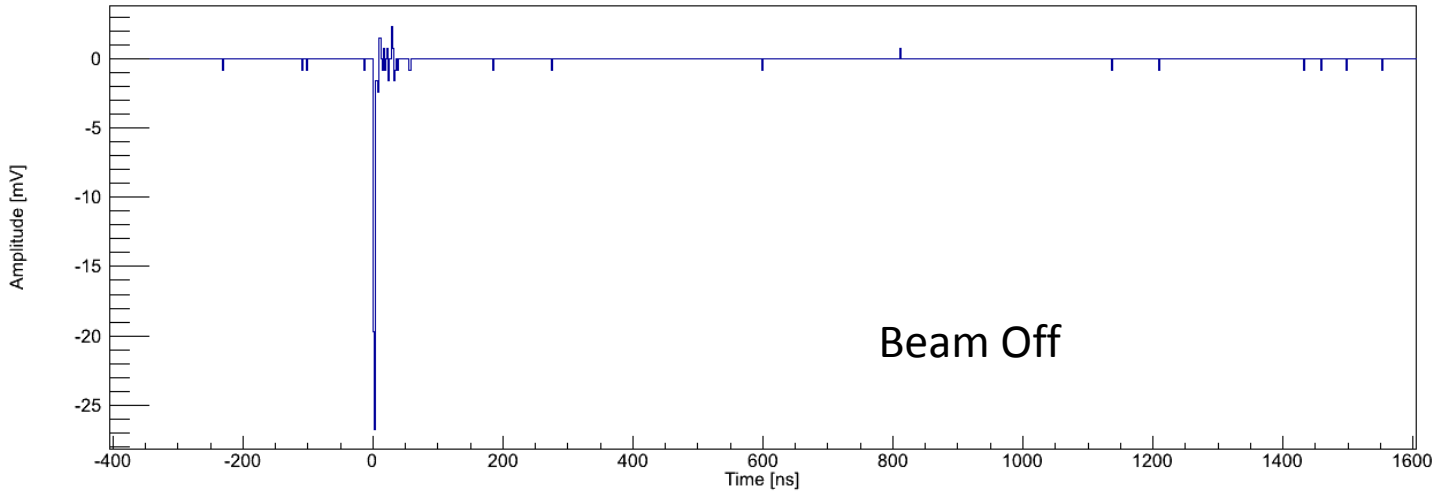
- Traditional charge integration method using two charge integration windows
- Prompt window without delay followed by delayed window

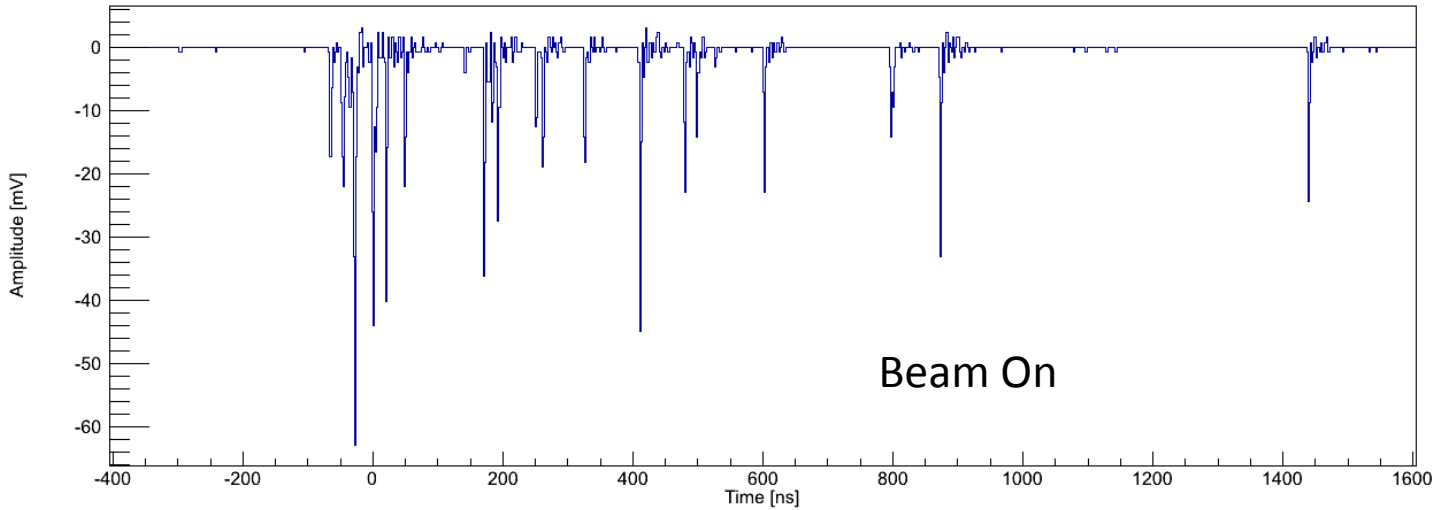


PSD ratio = $\dfrac{I_{delayed}}{I_{prompt}+I_{delayed}}$

NIST Center for Neutron Research

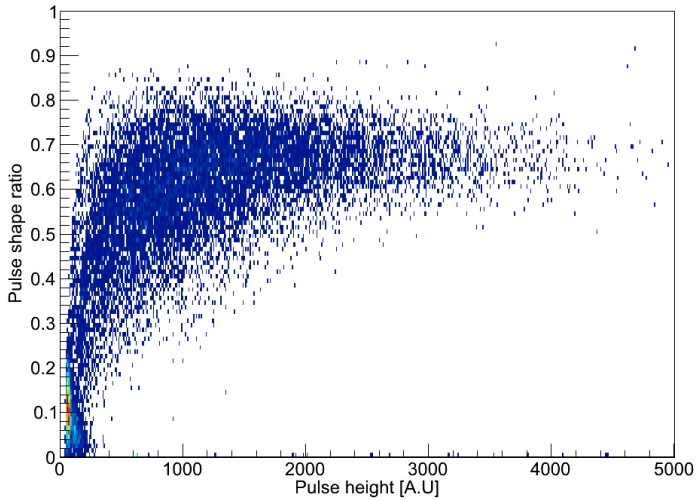
Raw Signal

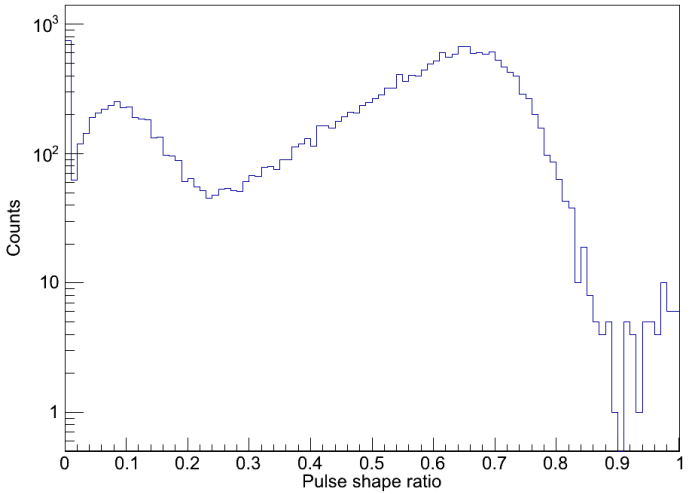


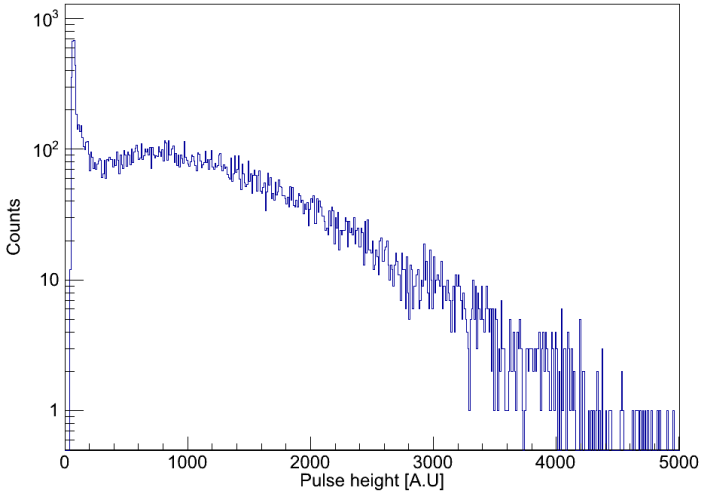


Center for
n Research

Gamma Discrimination (Beam On)

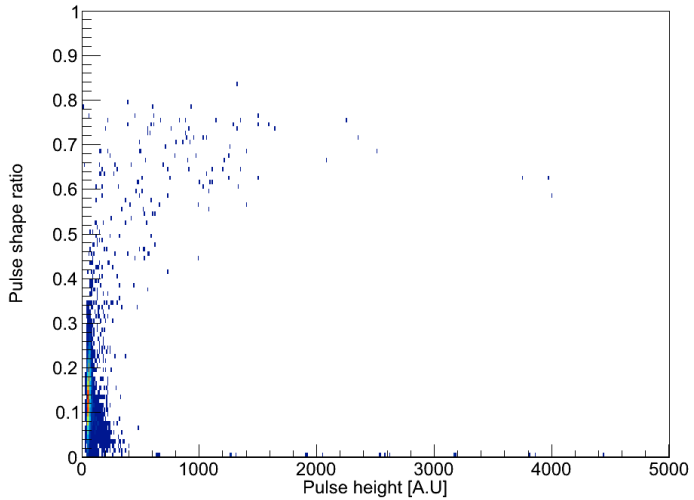


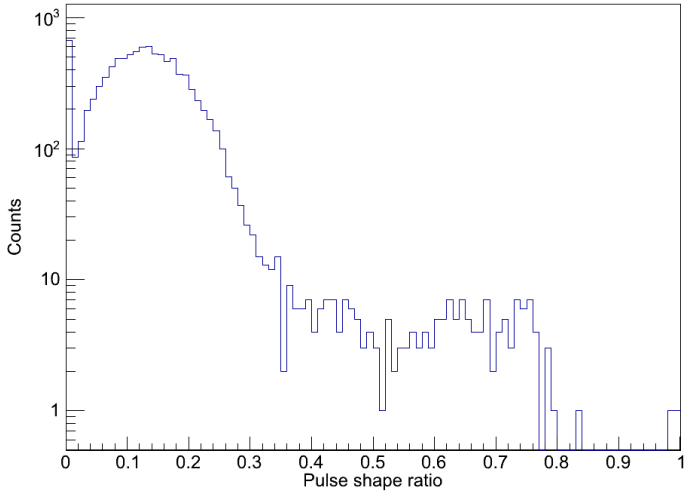


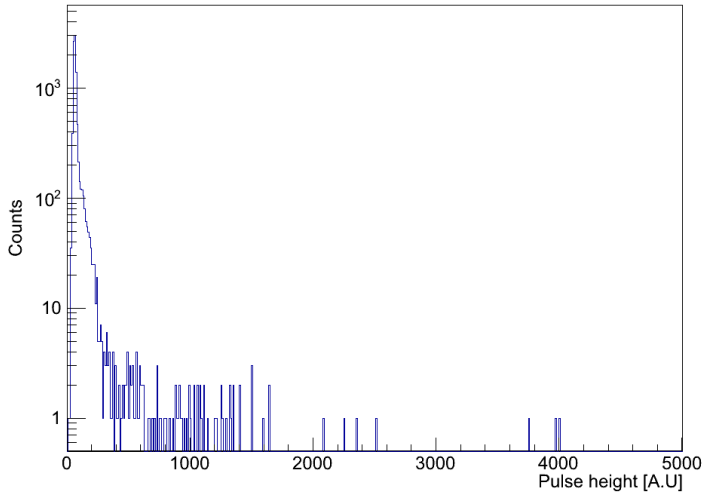


NIST Center for Neutron Research

Gamma Discrimination (Beam Off)

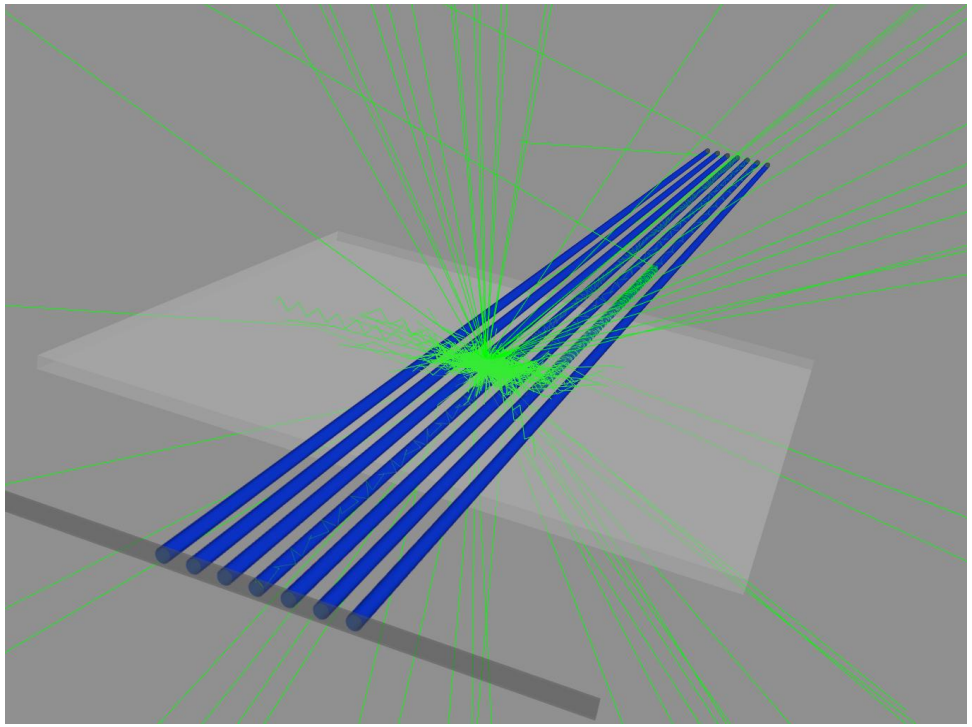






NIST Center for Neutron Research

GEANT4 Simulations



Simulations include:

Neutron capture

+

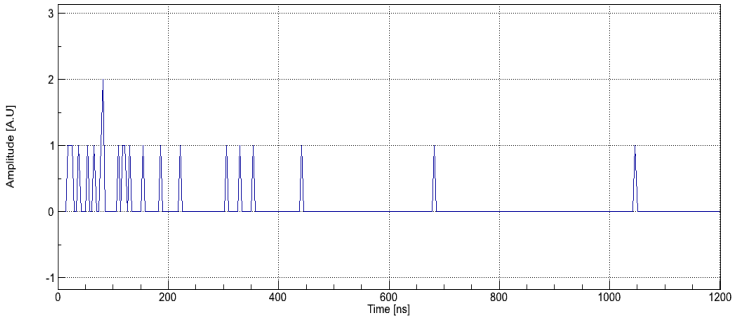
Scintillation

+

WLS collection and transmission

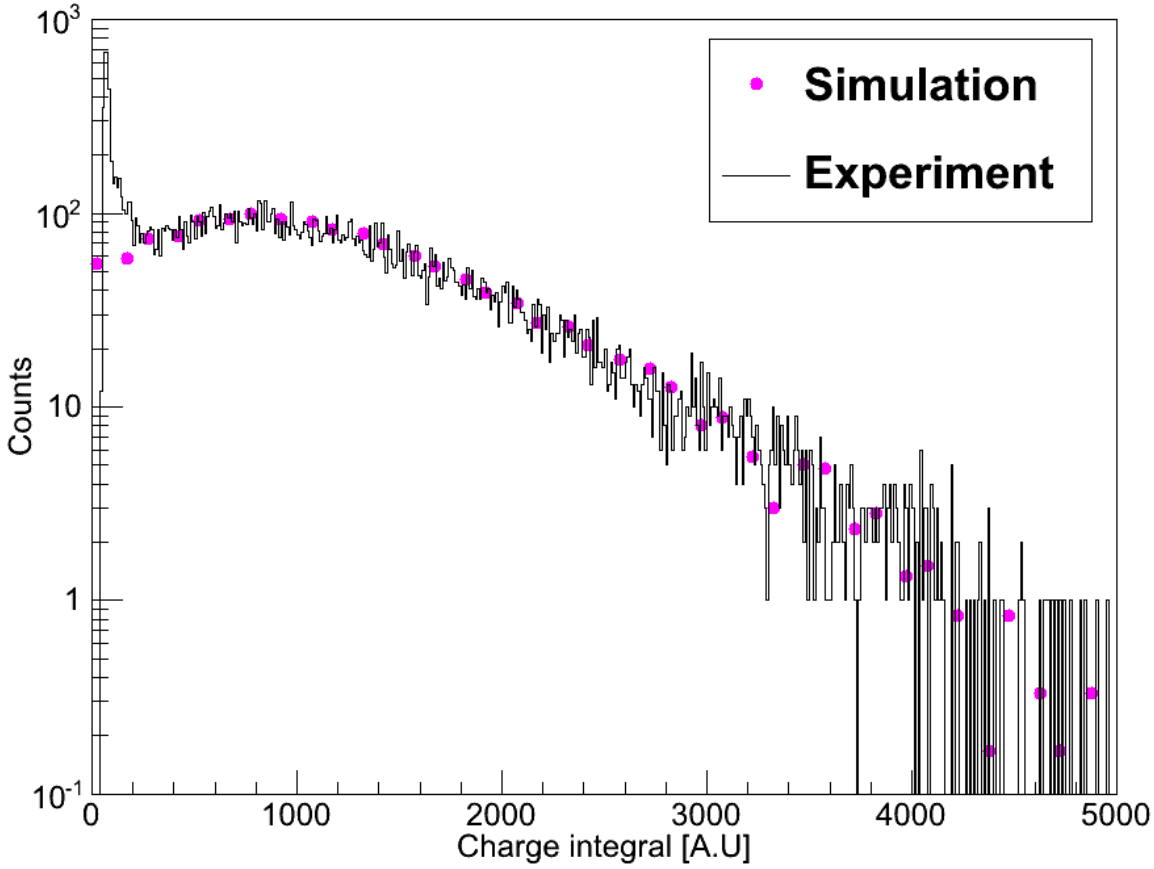
+

Photo Detection



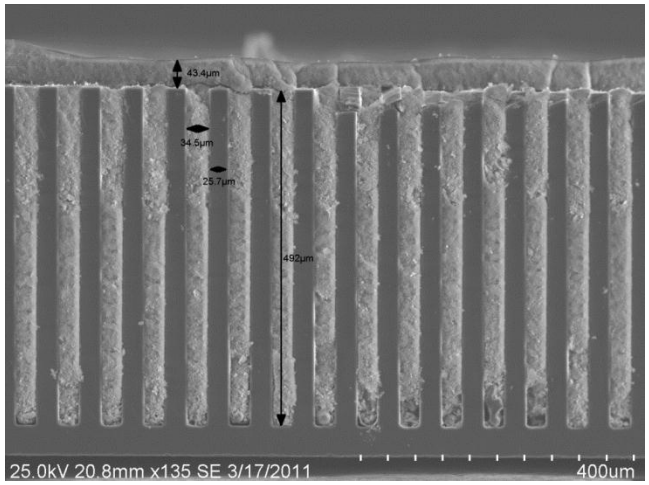
NIST Center for Neutron Research

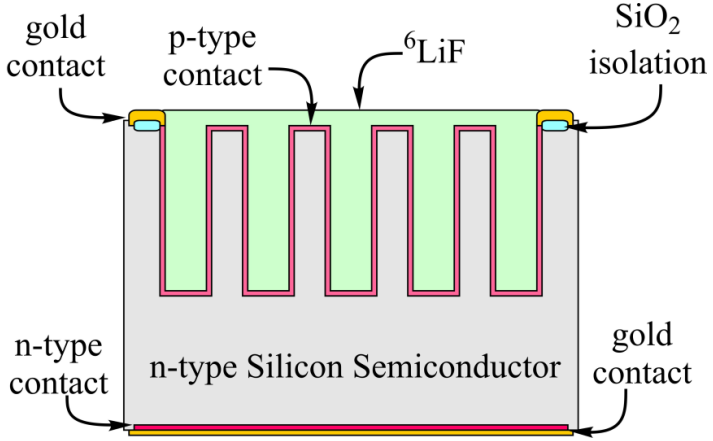
Comparison with Experiment



NIST Center for Neutron Research

Help From an Unexpected Source



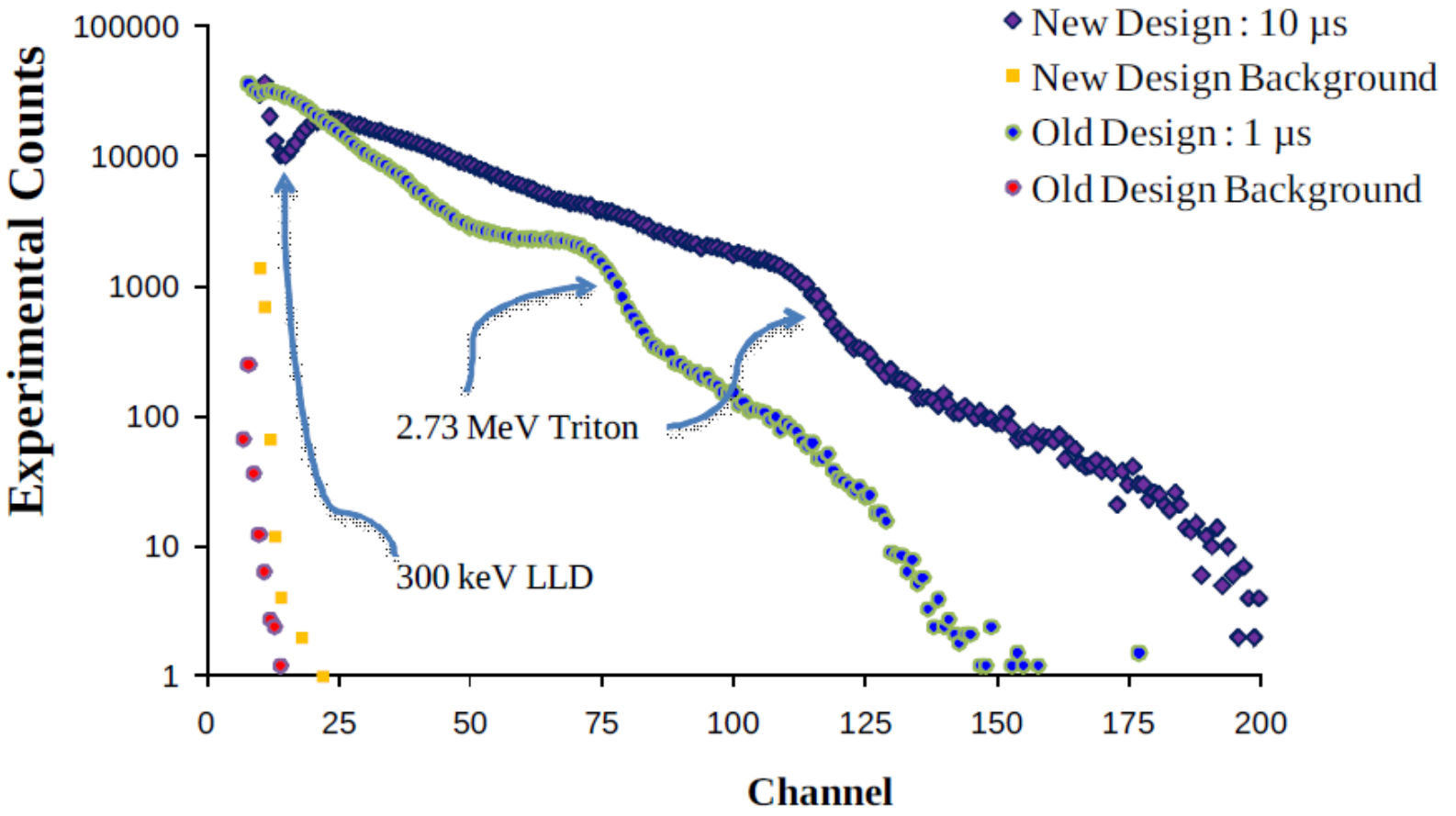


Kansas State University
Semiconductor Materials And Radiological Techniques (SMART) Laboratory
(Doug McGregor & Phil Ugorowski)

Microstructured Neutron Detectors (MSND)
- Patterned diodes with ^{6}LiF neutron converters
- Can be fabricated in 1cm × 3 cm × 1mm active volumes
- Measured thermal neutron efficiency ≈ 40%

NIST Center for Neutron Research

MSND Pulse Height Spectrum



Semiconductor Materials And Radiological Technologies

NIST Center for Neutron Research

Summary

- The NCNR is engaged in a detector development project funded by an intramural source
- The CANDOR instrument will use energy-analyzing modules with neutron sensitive elements
- Work has commenced to build tools and to characterize scintillator-based neutron sensors
- The NCNR is collaborating with KSU to evaluate a solid state alternative neutron sensor

NIST Center for Neutron Research